MODELLING OUTPUT GROWTH MEASUREMENT OF MACHINERY MANUFACTURING SMES

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ABSTRACT: *This study aims at developing a model to measure the output growth of machinery manufacturing SMEs. The ultimate target of the model is to evaluate the performance of machinery manufacturing SMEs In the earlier stage, a mathematical model is introduced based on literature review. Short term input-output data is used to test and validate the developed model. Model test revealed that estimated output growth is about 10% which is closer to actual output growth (about 7%). It is also found that estimated growth is significant at 95% confidence level. The findings demonstrate that the developed models are quite fit to evaluate the output growth and significance of growth. This study concludes that the objectives of this research are successfully achieved. This study has emphasized the importance of further study to build the model for evaluating engineering management contribution of output growth of machinery manufacturing SMEs*.

***Keywords*:** *Output* Growth; Manufacturing SMEs; Engineering Management; Input-Output: Production Perfromance.

1. INTRODUCTION AND BACKGROUND

This paper aims to develop a model to evaluate the output growth of machinery manufacturing SMEs. The developed model is being tested and refined with short term input-output data to evaluate the significance level of output growth.

Small and Medium Manufacturing Enterprises (SMEs) is critical to the future of economic growth and job creation within the developed and developing countries. In many developing countries, SMEs accounts for a significant share of employment and, therefore, it is directly connected to poverty alleviation. Nowadays, SMEs is challenged for the whole globalization in the business sector; therefore, new competitive determinants have been appeared to overcome and to find solution [1]. In result, SMEs can contribute to economic growth.

The machinery manufacturing SMEs is commonly categorized to be the component manufacturers for larger companies. Machinery manufacturing SMEs in developing countries are the most important for social and economic purposes including:

- Wide dispersion across rural areas and important for rural economies;
- The ability to employ a significant amount of the technical labours in local economies;
- Ability to provide opportunities for manufacturing entrepreneurial skills development [2].

However, the issues which are not fully addressed by the relevant stakeholders to reinforce its capability, are investigated including labour skills, optimization of capital, raw materials, engineering management capability for improving product quality, and production management capability. Basically, quality inputs to production process are the determinants of output growths. However, the model to evaluate the optimum level of outputs growth is not available in published literature. Hence, it is important to build output growth model for manufacturing SMEs. This study attempts to fill this gap by building and testing growth model related to the labour, capital, raw materials and engineering management.

This study has mainly five main sections: introduction and background is placed in section 1; the literature review and objectives are stated in section 2; theoretical framework and research methodology are described in section 3; research findings and conclusion are in section 4; following section, 5 which describes the conclusion.

2. LITERATURE REVIEW AND THEORETICAL FRAMEWORK

This section presents an overview of the literature review and theoretical framework related to manufacturing SMEs and its growth. From analysis the literature review; there has been a lack of empirical research on production evaluation growth manufacturing SMEs related to five components. Moreover, these studies have not tried to analyze and optimize the inputs-outputs with regards to production output. Most of the performance measurement growth models of machinery manufacturing SMEs does not have predictive power for future production performance with respect to output growth. In this regards, gaps are observed between existing performance measurement growth models and engineering management practices. The review work started to study academic research papers and textbooks on the conceptual model and manufacturing SMEs. Researchers studied over (23) papers and about (40) percent of these published before the year (2007); and about (60) percent papers published after (2010). Related titles which were taken into account during the research are presented and discussed here.

2.1 Outputs Growth Machinery Manufacturing SMEs

The production Growth of machinery manufacturing SMEs depends on the inputs resources of process. The output growth is influenced by the perceptions of managers and the physical inputs such as labour, capital, raw materials and engineering management [3]. According to resources such as knowledge, skills, routines, and assets controlled by a firm has become a vital factor to grow firms as mentioned by [4]. Therefore, firm growth implied a development process where a firm maintain balanced growth in total performance inputs [5]. Capital is an important issue in manufacturing SMEs for achieving business sustainability and production growth. It refers to money used by SMEs to purchase machinery, buildings, and raw materials in order to maintain operating cost. A major constraint for manufacturing SMEs is that they do not have access to formal financing system and business capitals [6]. In general, the SMEs has two sources of funds:

equity and debt. Equity refers to internal funds, including owners' savings and accumulated profits. Equity investments in SMEs refers to contribution from partners. Investments consist of personal investment from the entrepreneurs, private investments of friends or family, and venture capital investment [7]. To support production operation, business owners manage funds from convenient sources with respect to the business norms. However, the literature suggests that funding, team size, and growth are positively associated with an increase in productivity. The large teams possess more talents as stated by [8] and [9]. However, SMEs needs easy access to both formal and informal financial institutions for maintaining its growth.

Production and management skills play a vital role in manufacturing SMEs growth. Production growth depends on input factors and the job of operations manager is to manage; and the managers need to get involve efficiently in innovation and technology-based activities in order to reduce non-value added inputs to reduce capacity gap [10]. Generally, as stated previously, the major constraint of SMEs is capital and it is critical for SMEs to accept highly skilled operations and production engineer/manager in innovation activities for producing new products and processes to achieve sustainable growth of manufacturing SMEs [11].

The level of education and experience of the labour force is an important factor for manufacturing SMEs in growing phase. According to the study of manufacturing SMEs in Thailand by [12] asserted to operate with high levels of technical inefficiency. Such manufacturing SMEs is caught in a trap where production is heavily dependent upon labour input; predominantly unskilled labour in production is considered low value-added activities. Furthermore, the firms must know the best use of labour skills as suggested by [12]. Therefore, lesson learnt from Thailand manufacturing SMEs policy is that they need to focus on:

- increasing firm size through greater access to labour skilled.
- upgrading labour skills through improvements in education and training programme.

The study acknowledged the needs to improve the management of poor labour attitude in order to meet organizational challenge [13].

2.2 Theoretical Frame Work

2.2.1 Growth Model

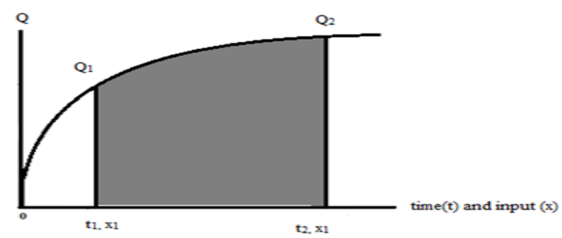
The theoretical literature on growth models are traditionally focussed on economics and agriculture. The relationship between productivity and growth has also featured in a number of theoretical contributions in particular models of evolutionary flavour that essentially posit that an economy's productive resources are reallocated from less productive to more productive firms [14]. The growth model is used in the current study presenting five measures of growth: labour, capital of machinery, raw materials, engineering management, and output.

Growth model is used to measure the contribution of different level inputs of production to growth. Inputs that have significant impact on production growth are:

- Labour skills
- Capital investment in new technologies in production machineries
- Quality of raw materials
- Engineering management and its elements such as R&D capability

Production growth happens when grouping of one or more of the inputs and changes in input growth process would mainly affect output growth [15];[16]. This can be represented by the production function.

The production function is a mathematical or graphical expression showing the relationship between the inputs used in production and the output growth. The production function gives a simple picture of the mechanism of production growth. The actual production growth involves of two factors which are time



Finger 1: Output Growth over Time

Over the time, labor, engineering, and R&D capability increase and this contributes to increase the output at the same input. This phenomenon can be presented by the following mathematical model:

$$\frac{\Delta Q}{\Delta t} = \frac{Q_2 - Q_1}{t_2 - t_1} \qquad (1)$$

2.2.2 The Growth Components

The growth rate of output that stated in Figure 1 and presented by equation (1) is a combined contribution effect of all inputs namely capital, labour, raw materials and engineering management. It implies that the contribution of each inputs a part of the ΔQ/Δt. The equation (1) is allowed to state that the contribution of an input to total growth is a ratio of the growth of an input components to total output growth. This logic could be presented by the following equation (2):

$$C(g) = \frac{\text{growth of components}}{\text{Total output grouth}} = \gamma \frac{g_i}{g_t} \qquad (2)$$

Here , g_i is the growth and γ is the efficiency components of of an individual inputs and g_t is the total growth of production process .

2.2.3 Time Effect on Growth

The contribution is not static and changes occur with the passage of time. A professional body or a technical person tends to gain experience over time which is used to enhance the contribution capability. This type of skill growth is known as the exponential distribution [17]. Therefore, the increasing capability of contribution can be presented by the equation (3):

$$A(t) = A_0\, e^{\theta t} \quad (3)$$

Here, θ = Time efficiency parameters of inputs of a production process is also known as a technological parameters [17]; [18]; [19]; [20] and [21]. Equation (3) indicates that the contribution is time dependent. If the equations (2) and (3) are combined; in results, the time dependent contribution model gets a new shape which presented by the equation (4)*:*

$$C_g(\mathrm{M}) = \gamma(t)\frac{gi}{gt}\, e^{\theta t} \quad (4)$$

Equation (4) indicates that the value of $C_g(\mathrm{M})$ depends on the elasticity of outputs $[\gamma\ (t)]$ and time efficiency parameter of skill $[\theta t]$.

2.2.4 Research Problem Statement

The central question of this research is **"what is the outputs growth behaviour of machinery manufacturing SMEs?"** This study is undertaken to address this issue and would be looking for answer of this question.

2.5 Objectives of the Study

The objectives of this study is

i. To develop a model for evaluating production output growth of machinery manufacturing SMEs
ii. To evaluate the significanne level of production output growth in machinery manufacturing SMEs.

2.5.1Scope of This Study

The scope of this study is to test output growth model of machinery manufacturing by using inputs–outputs data of 20 selected SMEs. Statistical Package of Social Sciences (SPSS) software was used for analyzing data. The analytical results have used to test the developed model. Basically this work is limited to model building of outputs growth and testing the model with selected SMEs outputs data.

2.5.2 Novelty of the Study

Production Model of manufacturing industries with engineering management components is essential; but this model is not available in the published literature. Furthermore, output growth of machinery manufacturing SMEs with respect to inputs of labour, capital, raw materials, and engineering management is also not available in published materials. This indicates that a gap exits in the machinery manufacturing SMEs domain and this study aims to fill up this gap. Hence, the **novelty** of this study is to develop an output growth model to evaluate the production performance of manufacturing SMEs growth.

3.0 METHODOLOGY

In this study, **short term production function** is used which is developed from Cobb Douglas production function. The developed model test that present in this paper is based on the data from twenty (20) machinery manufacturing SMEs. Following section presents the description of variables used in the current study.

3.1 Characteristics of Variables Used

3.1.1Dependent Variable:

The Output and output growth of machinery manufacturing SMEs

3.1.2 Explanatory Variables:

i. Capital- the amount of money used for purchasing machinery and equipment for manufacturing SMEs
ii. Labour- the amount of money that is being spent for labour for conducting manufacturing process operations.
iii. Raw Materials- The total cost of raw materials that are being used in production process.
iv. Engineering management- the total cost that are being used to manage engineering staff for planning, scheduling and R&D for smooth production operation of manufacturing SMEs.

3.2 Model Building to Evaluate the Growth

Inputs outputs modelling are practical to describe the flow of labour, capital, raw materials technology into the manufacturing process. The input-output model can also be used to measure the growth elements of process inputs to outputs. There are many ways to measure growth, but in the aspect of industrial production process; it is specific. The output growth of a industrial production depends on dynamic behaviour of inputs [22]:[23]. This study used labour, capital, raw materials, and engineering management to measure output growth. However, output growth measurement model can be developed from **short term production function**, which is shown in equation (5)

$$Log\ (Q) = Log\ (A) + \alpha Log\ (K) + +\lambda\ Log(R) + \beta\ Log\ (L) + \gamma\ Log\ (M) \quad (5)$$

Here; $Q(t)$=Average output of production over time t. K= capital of machinery and production operations. R = Raw materials used. L= number of labour on the manufacturing process. A= transformation factor from inputs to outputs, M= engineering management needs to manage production. The conceptual model of outputs growth model with inputs is shown in Figure 2 below.

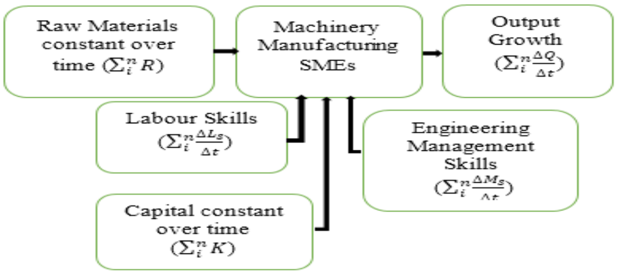


Figure.2: Conceptual Growth Model

3.3.1 Growth Model of Labor

$$G(L) = \frac{1}{L}\left(\frac{dl}{dt}\right) \quad (6)$$

Where, $G(L)$ is the output growth rate that contributed by labor (L) with respect to time (dl/dt).

3.3.2 Growth Model of Capital

This growth is due to increase production growth over time.

$$G(k) = \frac{1}{k}\left(\frac{dk}{dt}\right) \quad (6a)$$

Where, $G(K)$ is the output growth rate that contributed by Captal with respect to time (dk/dt).

3.3.3 Growth Model of Raw Materials

This growth is due to increase production over time

$$G(R) = \frac{1}{R}\left(\frac{dR}{dt}\right) \quad (6b)$$

Where, G (R) is the output growth rate that contributed by Raw materials (R) with respect to time dR/dt

3.3.2 Growth Model of Engineering Management

$$G(M) = \frac{1}{M}\left(\frac{dm}{dt}\right) \quad (7)$$

Where, $G(M)$ is the output growth rate that contributed by engineering management with respect to time (dm/dt). This growth is due to skills growth of engineering staff lover time.

The output growth model of machinery manufacturing SMEs can be obtained by combining equation from (6) to (7) which shows equation (8);

$$G(Q) = \alpha_1 G(K) + \beta_1 G(L) + \lambda_1 G(R) + \gamma_1 G(M). \quad (8)$$

Where, $\alpha_1, \beta_1, \lambda_1$ and γ_1 = factor efficiency parameters.

The value , α, β, λ and γ can be obtained from equation (5).

3.4 Modelling to Evaluate the Significant Level of Output Growth

The output growth significancy can be measued in various ways. Commonly, at 0.05 significant and 95% confident level or . at 0.1 significant and 90% confident leve is being used. The P-value is commononly used to evaluate the significancy level . The mathamtical model of significancy is shown in equation (9) .

This study can estimate P-value by used the equation number (9) stated below:

$$Z = \frac{(\bar{X}-x)}{\frac{\sigma}{\sqrt{n}}} \quad (9)$$

Where; σ is the standard devotion of G (Q) in SMEs, n is the sample size of SMEs and $x_{(i,\ldots,n)}$ is the G (Q) to production 20 SMEs within operating time 2009-2013 and $\bar{X}$ is the average of G (Q). The meaning of p-value demonstrates in Figure 3.

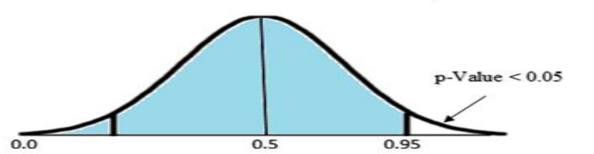


Figure. 3: Sginfcant Level Growth Test

The signifiancy is measued at 95% level the Figure 3 demonstrates that if the P- value is less 0.05 then it is signifiant. Similarly, if P-value is more 0.05 than then it is not significant.

4. MODELS ESTIMATE

This study uses time-series data of 2009-2013. First, according to equation (5) evaluate the outputs of machinery manufacturing SMEs growth; second, according to equations (6),(7)and (8) evaluate the contribution of inputs to outputs of machinery manufacturing SMEs growth , and equations (9) for measuring the level significance of contribution engineering management to grow production manufacturing SMEs.

4.1 Data Analysis and Findings

Inputs-outputs data of 20 SMEs on the 5 years production is analysed; and findings are reported in Table 01. Details analysis form the output of SPSS is attached in Appendix A1

Table 1: Model Estimate of 20 Machinery Manufacturing SMEs

Param e-ters	α_1	β_2	$\lambda 1$	$\gamma 1$	R^2	DW
Mode esimate	**0.076**	**0.761**	**0.73**	**0.77**	**0.992**	**2.309**

The value of effect size (R^2) is 0.992 indicates that 99.2 percent inputs has used in outputs. The DW statistics 2.3 indicates that auto correlation is within acceptable limit. The estimated value of output growth rate of labor labour, capital, raw materials and engineering management are $\alpha 1=0.761$, $\beta 1=0.076$, $\lambda 1=0.73$ and $\gamma 1 = 0.77$ respectively.

4.2 Growth Model Estimate of Machinery Manufacturing SMEs

This part of the analysis is designed to address the research objective (i). The short term input-output data have been used to estimate output model (8). The detail analysis is attached in Appendix A2. The estimated value of growth coefficients is listed in Table 1. The final shape of output growth model is shown in Equation (10).

$$G(Q) = 0.076G(K) + 0.761G(L) + 0.73G(R) + 0.77G(M) \quad (10)$$

The value $0.076\ G\ (K)$ indicates that contribution of capital to outputs growth is 0.076; $0.761\ G\ (L)$ contribution of labour contribution to outputs growth is 0.761, $0.73\ G\ (R)$ contribution of raw materials to outputs growth is 0.73 and $0.77G\ (M)$ contribution to engineering management to outputs growth is 0.77. The model Equation (10) has esteemed for 20 SMEs and reported in Table 2

Table 2: Estimate Growth of 20 SMEs

Industry	Avreage β*Gr(L)	Avreage α*Gr(K)	Avreage λ*Gr(R)	Avreage γ*Gr(M)	Avreage G(Qt)	P-value
SMEs1	0.04814	-0.0115	0.05708	0.07261	0.16632	0.0002*
SMEs2	0.07738	0.00179	0.09672	0.08746	0.26334	0.3821
SMEs3	0.05423	0.00486	0.06686	0.07003	0.196	0.0055
SMEs4	0.02502	0.00553	0.00103	0.02505	0.05663	0.0003*
SMEs5	0.19643	0.02142	0.16663	0.19043	0.57491	0.0003*
SMEs6	0.02114	0.0002	0.03408	0.01103	0.06645	0.0003*
SMEs7	-0.0067	-0.005	0.03451	-0.0032	0.01962	0.0002*
SMEs8	0.02108	0.00125	0.03157	0.02969	0.0836	0.0003*
SMEs9	0.19643	0.01691	0.20039	0.24006	0.65381	0.0003*
SMEs10	0.01663	0.00537	-0.0139	0.01453	0.02265	0.0003*
SMEs11	-0.0067	0.00181	-0.0173	0.01679	-0.0054	0.0003*
SMEs12	0.01816	0.00241	0.02182	0.02957	0.07196	0.0003*
SMEs13	0.01913	0.00352	0.00687	0.02686	0.05637	0.0003*
SMEs14	0.07738	0.00847	0.06653	0.08693	0.23931	0.2389
SMEs15	0.02108	0.00058	0.03639	0.02502	0.08306	0.0003*
SMEs16	0.04814	0.00927	0.0111	0.06953	0.13805	0.0003*
SMEs17	0.02108	0.00566	0.00151	-0.0059	0.02232	0.0003*
SMEs18	0.02108	-0.0143	0.14992	0.03118	0.18785	0.0188
SMEs19	0.01913	0.00632	0.00181	0.01739	0.04465	0.0003*
SMEs20	0.02108	0.08427	2.03105	0.04673	2.18313	0.0003*
Average	**0.04546**	**0.00744**	**0.14923**	**0.05409**	**0.25623**	**0.032495***

*One tail test at 95% confidence level

The developed models are used to measure the growth and significance level. Results show that growths of 16 SMEs out of 20 are significant.

4.3 Significance Test

Signfacantcy Test for growth SMEs 1 is depicted in Figure 4 and detail of other analysis are attached in Appendix A3**.**

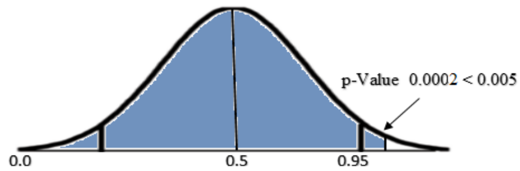


Figure 4: Significant Test of Growth for SMEs1

The significant test is conducted at 95 percent confidence level. The p-value of contribution to growth is found to be 0.0002 which is less than 0.005. The location of p-value is outside 0.95. Which indicates that contribute of inputs to outputs growth is significant. This findings allow us to state that the develop model is quite fit to evaluate the growth of machinery manufacturing SMEs.

4.4. Scenario Analysis of Findings

Model estimate of production function, output growth, and significance measurement are reported in section 4.1, 4.2, and 4.3. The findings demonstrated the relationship between inputs and outputs of growth production process. Model test results have indicated that the major contributory growth element of the production process is a raw material with technical efficiency 0.73. The second highest growth contributor is the engineering management with its technical efficiency 0.77. The third contributing input element is the labour with technical efficiency 0.761 and finally the lowest growth contributing elements is the capital with technical efficiency 0.076. However, the growth measurement model presented by equation (10) shows that that model is effective in evaluating the output growth of 20 machinery manufacturing SMEs. The validation of the model is conducted by comparing the model estimate and actual growth of the 20 SMEs. The Validation results are listed in Table 2.

Table 2: Model validation

Industry	Model Estimate (%)	Actual growth (%)
SMEs1	16.63	16.3
SMEs2	26.33	13.5
SMEs3	19.6	12
SMEs4	5.66	5.6
SMEs5	5.71	7.6
SMEs6	6.64	9.3
SMEs7	19.62	8.1
SMEs8	8.36	7.6
SMEs9	.6.53	6.6
SMEs10	2.26	5.3
SMEs11	5.41	4.1
SMEs12	7.19	5.2
SMEs13	5.63	7.2
SMEs14	23.91	6.7
SMEs15	8.30	6.1
SMEs16	13.80	6.0
SMEs17	2.23	7.1
SMEs18	18.78	5.8
SMEs19	4.46	7.2
SMEs20	2.13	5.8

Average	**10.66**	7.65

The model estimate and actual outputs growth of 20 SMEs is listed in Table 2 which indicate the both are nearly same. This finding reveals that developed model is quite fit to evalue the output growth of machinery machufacturing SMEs. Thus, our objective no one that we have stated in 2.3.3(i) is achieved. Moreparticulary, the output growth of 16 SMEs is appeared to be significant at 95% level(p-value <0.05). This finding suggests that objective no two is achieved and stated in 2.3.3(ii).

5 CONCLUSION AND SUMMARY

The aim of this study was to build and test a growth model to evaluate the output growth of machinery manufacturing SMEs. To conduct thus study we used input-outputs data of 20 SMEs of 2009-2013 periods to test and validate of the developed model.The findings demonstrate that the developed model is quite fit to evalute the output growth and significance of growth. This study concludes that the objectives of this research are sucessfully achieved. This study has emphasised the importance of further study to build the model for evaluat ingengineering management contribution to output growth of machinery manufacturing SMEs.

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Appendix A1

SPSS Output

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.996[a]	.992	.992	.02709	.992	2425.751	4	75	.000	2.309

a. Predictors: (Constant), GM, GR, GK, GL

b. Dependent Variable: GQ

Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B		Collinearity Statistics	
		B	Std. Error	Beta			Lower Bound	Upper Bound	Tolerance	VIF
1	(Constant)	.000	.003		-.038	.970	-.006	.006		
	GL	.761	.051	.704	14.944	.000	.660	.862	.046	21.728
	GK	.076	.008	.120	9.808	.000	.061	.092	.681	1.468
	GR	.073	.003	.312	28.212	.000	.068	.079	.834	1.199
	GM	.077	.044	.083	1.760	.082	-.010	.164	.046	21.708

a. Dependent Variable: GQ

AppendixA2

Estimate growth model on SMEs1

$G\,(Qt) = 0.076G\,(K) + 0.761G\,(L) + 0.73G(R) +$
$0.77G\,(M),$

$G\,(Qt)$ = 0.761*(0.063258094) +0.076*(-0.151515581) + 0.73*(0.078189629) +0.77 * (0.094302068),

$G\,(Qt)$ =0.166315247

Appendix A3

Estimate P-value for measuring output growth SMEs1 by Using Z-test: $Z = \frac{(\bar{X}-x)}{\frac{\sigma}{\sqrt{n}}}$ for

Standard deviation: $\sigma = \sqrt{1/n\,(x_i - \mu)^2}$

Where; σ is the standard devotion of G (Q) in SMEs,

N is the sample size of SMEs and x_i is the average G (Q) to twenty SMEs within operating time 2009-2013; μ is the total average of G (Q); $\bar{X}$ is the total average of G (Q)

$\sigma = \sqrt{1/20\,(\,0.224565181)^2}$ = 0.10596348

Then $Z = \frac{\sqrt{20}*((\bar{X}-x))}{0.10596348} = \frac{0.402100641}{0.10596348}$= 3.794709665, the value from the Z-table is 0.998

P-vale =1- P, 1- 0.9998 = 0.0002.

Significant level growth test SMEs